CERTIFICATION

I, Yoshihiro Iwasaki, 26-10, Tenjin 2-chome, Nagaokakyo-shi, Kyoto-fu, Japan, do hereby certify that I am conversant with the English and Japanese language, and I further certify that to the best of my knowledge and belief that the attached English translation is a true and correct translation of the Japanese Patent Application No. 2000-341675.

Date: August 12, 2004

岩崎好洋

Yoshihiro Iwasaki

JP Application No. 2000-341675

[Name of Document] Application for Patent

[Reference No.] 10438

[Addressee] Commissioner of the Patent Office

[Int. Cl.] H03H 9/58

[Inventor]

[Address] c/o Murata Manufacturing Co., Ltd., 26-10, Tenjin 2-chome, Nagaokakyo-shi, Kyoto-fu

[Name] Masakazu YAMAUCHI

[Applicant for Patent]

[Id. No.] 000006231

[Name] Murata Manufacturing Co., Ltd.

[Representative] Yasutaka MURATA

[Agent]

[Id. No.] 100085497

[Patent Attorney]

[Name] Hidetaka TSUTSUI

[Application Fees]

[Prepayment Registration No.] 036618

[Amount of Payment] 21000

[List of Documents Attached]

[Name of Document] Specification 1

[Name of Document] Drawings 1

[Name of Document] Abstract 1

[No. of General Power of Attorney] 9004890

[Proof] Required

JP Application No. 2000-341675

[Name of Document] SPECIFICATION

[Title of the Invention] THREE-TERMINAL FILTER USING AREA FLEXURAL VIBRATION MODE

[Claims]

[Claim 1] A three-terminal filter using an area flexural vibration mode, comprising: three electrodes having virtually the shape of a square; and two piezoelectric layers having virtually the shape of a square, wherein each of the electrodes and each of the piezoelectric layers are alternately laminated,

the piezoelectric layers are polarized in the same direction as, or in the opposite direction to a thickness direction, one of the surface electrodes is used as an input electrode, the other of the surface electrodes is used as an output electrode, and an internal electrode is used as a ground electrode.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a three-terminal filter using an area flexural vibration mode for use, for example, in an AM filter and the like.

[0002]

[Description of the Related Art]

Known three-terminal filters used in a kHz band include a

filter using an area expansion vibration mode or a filter using a length vibration mode.

Fig. 1 illustrates an example of an AM three-terminal filter B using an area expansion vibration mode.

In this filter B, a center electrode 11 is formed on the central portion of the surface of a piezoelectric ceramic substrate 10, which is virtually square in shape, a ring electrode 12, which surrounds the center electrode 11, is formed on the outside thereof, and a ground electrode 13 is formed on the entire back surface. An input terminal 11a, an output terminal 12a, and a ground terminal 13a are connected to the center electrode 11, the ring electrode 12, and the ground electrode 13, respectively.

Fig. 2 illustrates a circuit mark of the three-terminal filter B of Fig. 1.

[0003]

[Problems to be Solved by the Invention]

In the case of the three-terminal filter B using the an area expansion vibration mode described above, the resonance frequency is determined by the length of one side of the three-terminal filter B. For example, if a 40 kHz filter is desired, the length of one side of the filter is as long as 50 mm.

In recent years, miniaturization of electronic devices has been increasingly advanced, and thus, electronic components

are also required to be made smaller and thinner. Under these circumstances, a large filter as described above can hardly be employed. Therefore, three-terminal filters using an area expansion vibration mode have been only applicable for filters having a frequency of several 100 kHz or more. In the case of a three-terminal filter using a length vibration mode, in the same manner as the filters using an area expansion vibration mode, since the resonance frequency is determined by the shape (length) thereof, its miniaturization has been difficult.

[0004]

Accordingly, it is an object of the present invention to provide a three-terminal filter using an area flexural vibration mode, which can be made smaller than the filters using an area expansion vibration mode or a length vibration mode, and in which the frequency can be adjusted by selecting the thickness and the length of the filter. Moreover, another object of the present invention is to provide a three-terminal filter which achieves a lower frequency if a filter has the same size.

[0005]

[Means for Solving the Problems]

In order to achieve the above-described object, according to the present invention, there is provided a three-terminal filter using an area flexural vibration mode, including:

three electrodes having virtually the shape of a square; and two piezoelectric layers having virtually the shape of a square, wherein each of the electrodes and each of the piezoelectric layers are alternately laminated, the piezoelectric layers are polarized in the same direction as, or in the opposite direction to a thickness direction, one of the surface electrodes is used as an input electrode, the other of the surface electrodes is used as an output electrode, and an internal electrode is used as a ground electrode.

[0006]

In the case of a resonator using a rectangular bending vibration mode, a long-side bending vibration and a short-side bending vibration occur. However, as the shape of the resonator approaches to a square, the frequency of the short-side bending vibration comes close to that of the long-side bending vibration. When the resonator finally becomes a square, both of the long-side bending vibration and the short-side bending vibration overlap, thereby generating a very large area flexural vibration.

In the case of a resonator using the area flexural vibration mode, the piezoelectric layers, in which the direction of the polarization and the direction of the electric field are the same, contract in a direction of a flat surface. The piezoelectric layers, in which the direction of the

polarization and the direction of the electric field are the opposite, expand. Therefore, an area flexural vibration mode is generated in the resonator on the whole. In such a resonator using an area flexural vibration mode, compared with a piezoelectric resonator using an area expansion vibration mode, if both resonators have the same resonance frequency, the size of the resonator using an area flexural vibration mode can be made smaller. On the contrary, if both resonators are the same size, a filter having a lower frequency can be obtained.

In a resonator using an area expansion vibration mode, the resonance frequency thereof is determined only by the length of one side. In contrast, in a resonator using an area flexural vibration mode, the resonance frequency thereof is determined not only by the length of one side, but also by the thickness of the resonator. Therefore, the resonance frequency can be adjusted by selecting the side length and the thickness of the resonance element.

Moreover, in the resonator using an area flexural vibration mode, because two piezoelectric layers are laminated, even when the overall thickness is the same, each piezoelectric layer can be made to have an about 1/2 thickness, compared with the resonator using an area expansion vibration mode. Therefore, the capacitance between the terminals, that is to say, the capacitance between the input electrode and the

ground electrode, and the capacitance between the output electrode and the ground electrode can be made about double as large as the original capacitance.

[0007]

[Description of the Embodiment]

Fig. 3 and Fig. 4 illustrate a first embodiment of the three-terminal filter using an area flexural vibration mode according to the present invention.

This filter A includes two piezoelectric layers (piezoelectric ceramics layers) 1 and 2 having substantially the shape of a square, which are laminated with an internal electrode 3 sandwiched therebetween. Surface electrodes 4 and 5 are formed on the outer main surfaces of the laminated piezoelectric layers 1 and 2, respectively. The thickness of both of the piezoelectric layers 1 and 2 is set to be the same.

The internal electrode 3 is connected to a ground terminal 3a, one surface electrode 4 is connected to an input terminal 4a, and the other surface electrode 5 is connected to an output terminal 5a. A circuit diagram at this time is the same as Fig. 2.

[0008]

The piezoelectric layers 1 and 2 may be polarized in any of the following directions: in the same direction as the thickness direction as shown by (a) in Fig. 5, in the

outward directions opposite to each other as shown by (b), and in the inward directions opposite to each other as shown by (c).

[0009]

For example, as shown by (b) in Fig. 5, in the case of the filter A having piezoelectric layers 1 and 2, which are polarized P in the opposite directions to each other, when a positive potential is applied to the input terminal 4a and a negative potential is applied to the output terminal 5a, an electric field E is produced in a direction extending from the surface electrode 4 to the surface electrode 5. The piezoelectric layer 1, in which the polarization direction is the opposite to the electric field direction, expands in the direction of the flat surface. The piezoelectric layer 2, in which the polarization direction is the same as the electric field direction, contracts in the direction of the flat surface. Therefore, as shown in Fig. 6, the filter A bends to become upwardly convex on the whole. If the direction of the electric field is the opposite, the filter A bends to become downwardly convex. Therefore, if a high-frequency electric field is applied between the input terminal 4a and the output terminal 5a, the filter A vibrates in an area flexural vibration mode at a desired frequency.

[0010]

Fig. 7 shows the amplitude characteristic and the group-delay characteristic (GDT) of the filter A described above. As is apparent from Fig. 7, favorable filter characteristics are shown.

[0011]

In the case of a resonator using an area expansion vibration mode, the resonance frequency is determined only by the side length of the resonator, and is not affected by the thickness of the resonator. In contrast, in a resonator using an area flexural vibration mode, the resonance frequency Fr is determined by the thickness t and the side length L as shown by the following formula:

$Fr \propto t/L^2$

In this manner, the resonance frequency Fr is proportional to the thickness t, and is inversely proportional to the square of the side length L.

[0012]

In Fig. 8, a comparison is made between the element size of the filter A using an area flexural vibration mode and that of the resonator using an area expansion vibration mode at the same frequency (Fr = 40 kHz).

As is apparent from the figure, even at the same frequency, the element size in an area flexural vibration mode can be made about 1/5 as small as that in an area expansion vibration mode. In particular, in the case of the three-

terminal filter for Fr = 40 kHz, the length of one side becomes about 50 mm for an area expansion vibrating element. However, for an area flexural vibrating element, the length of one side can be made about 10 mm or less. In particular, if the thickness of an area flexural vibrating element is made about 0.2 mm or less, the side length of the element can be made as small as about 5 mm or less.

[0013]

[Advantages]

As is apparent from the above description, according to the present invention, a three-terminal filter includes three electrodes and two piezoelectric layers, each of which is alternately laminated, and the piezoelectric layers are polarized in the thickness direction, wherein one of the surface electrodes is used as an input electrode, the other of the surface electrodes is used as an output electrode, and an internal electrode is used as a ground electrode. Thus, the two piezoelectric layers vibrate in an area flexural vibration mode, in which the two piezoelectric layers are the opposite to each other. Therefore, the size of filter can be reduced compared with a filter using an area expansion vibration mode or a filter using a length vibration mode even at the same frequency. On the contrary, when the filters are the same size, a three-terminal filter having a lower frequency can be obtained.

Also, since the frequency can be adjusted by selecting the thickness and the side length, three-terminal filters having various frequencies can be obtained.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a perspective view of an example of a three-terminal filter using a known area expansion vibration mode.

[Fig. 2]

Fig. 2 is a circuit diagram of the three-terminal filter shown in Fig. 1.

[Fig. 3]

Fig. 3 is a perspective view of an example of a three-terminal filter according to the present invention.

[Fig. 4]

Fig. 4 is a sectional view of the three-terminal filter shown in Fig. 3.

[Fig. 5]

Fig. 5 is a diagram illustrating the polarization directions of the three-terminal filter shown in Fig. 3.

[Fig. 6]

Fig. 6 is a diagram of a state in which the three-terminal filter shown in Fig. 3 vibrates in an area flexural vibration mode.

[Fig. 7]

Fig. 7 is a filter characteristic diagram of the three-

terminal filter shown in Fig. 3.

[Fig. 8]

Fig. 8 is a diagram illustrating the relationship between the thickness and the one-side length of a three-terminal filter using an area flexural vibration mode and that of a three-terminal filter using an area expansion vibration mode.

[Reference Numerals]

A three-terminal filter

1, 2 piezoelectric layers

3 internal electrode

3a ground terminal

4, 5 surface electrodes

4a input terminal

5a output terminal

JP Application No. 2000-341675

[Name of Document] ABSTRACT

[Abstract]

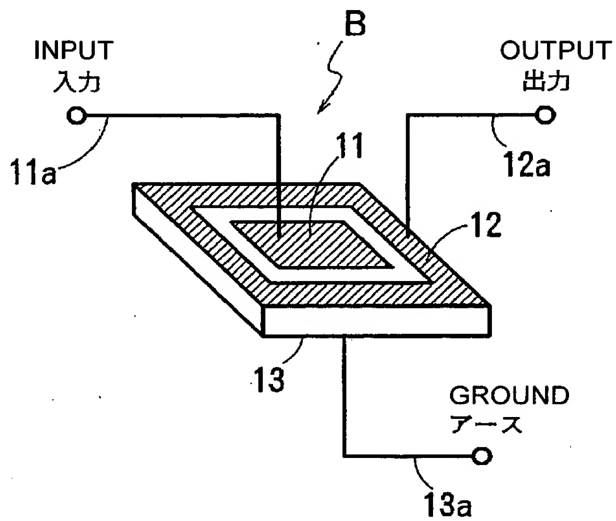
[Object] To provide a three-terminal filter using an area flexural vibration mode, which can be miniaturized compared with a filter using an area expansion vibration mode or a filter using a length vibration mode, and in which the frequency can be adjusted by selecting the thickness and the side length.

[Solving Means] A three-terminal filter includes: three electrodes 3, 4, and 5 having virtually the shape of a square; and two piezoelectric layers 1, 2 having virtually the shape of a square, wherein each of the electrodes and each of the piezoelectric layers are alternately laminated, the piezoelectric layers 1, 2 are polarized in the same direction as, or in the opposite direction to a thickness direction. One of the surface electrodes 4 is used as an input electrode, the other of the surface electrodes 5 is used as an output electrode, and the internal electrode 3 is used as a ground electrode.

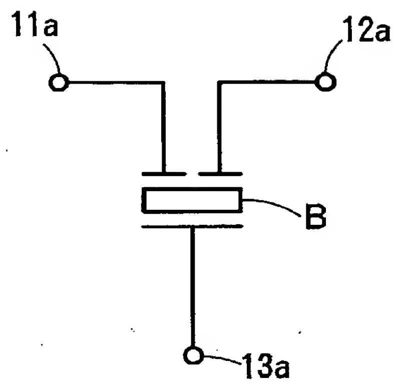
[Selected Figure] Fig. 4

【書類名】　図面　[Name of Document] DRAWINGS

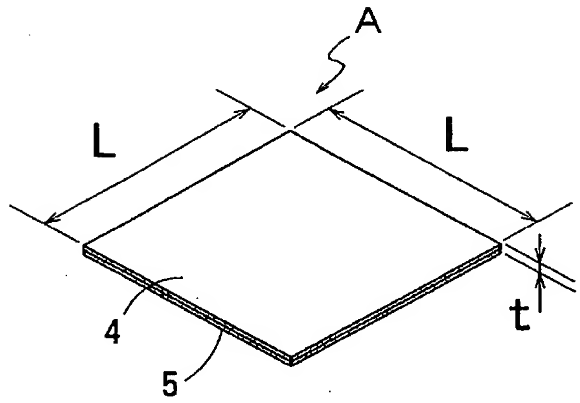
【図１】 [FIG. 1]



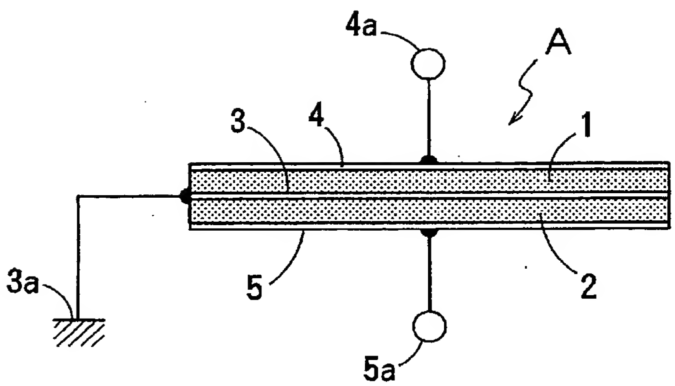
【図２】 [FIG. 2]



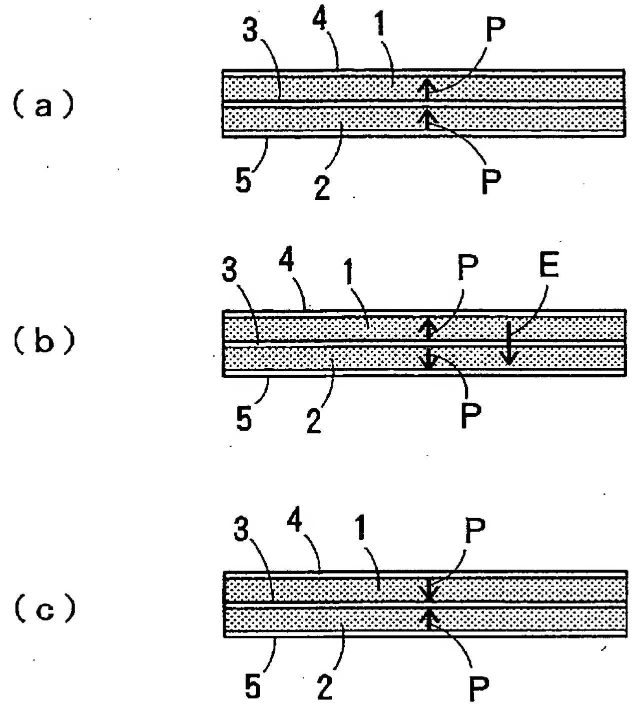
【図３】 [FIG. 3]



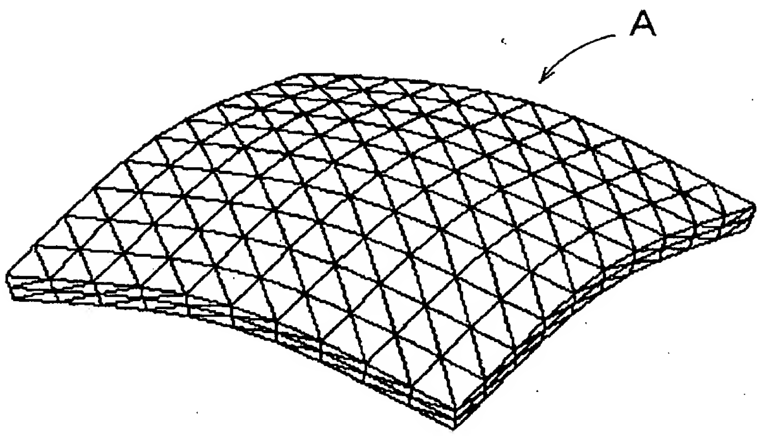
【図４】 [FIG. 4]



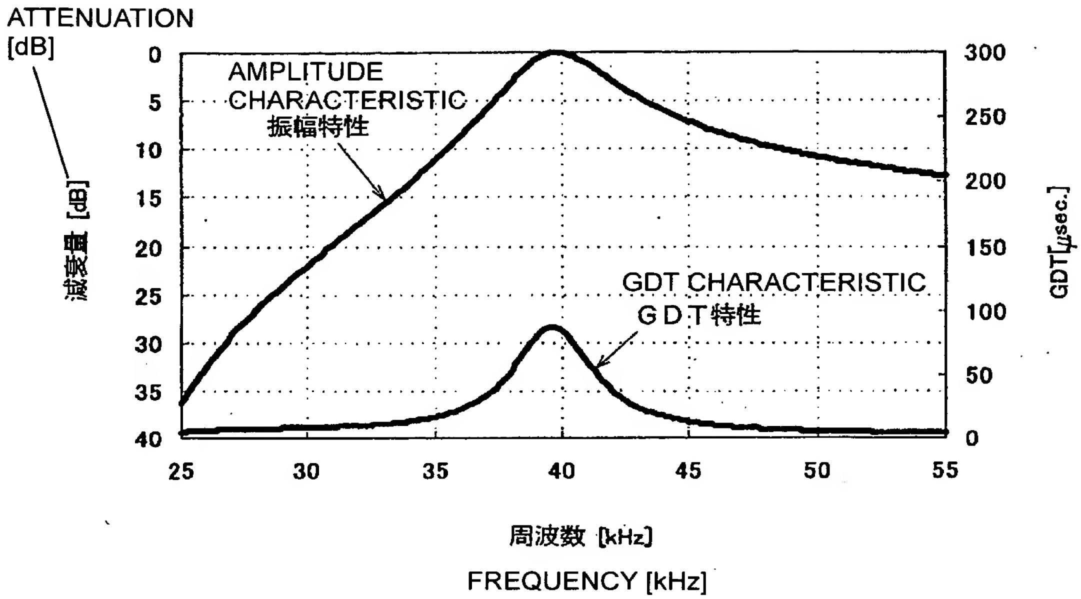
【図５】 [FIG. 5]



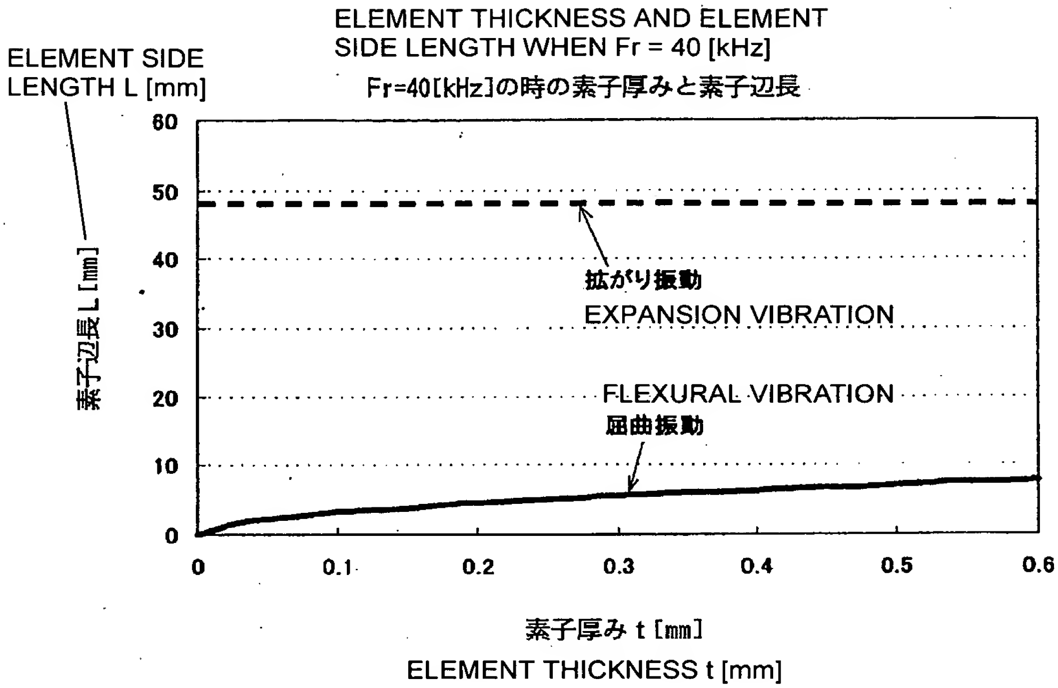
【図６】 [FIG. 6]



【図７】 [FIG. 7]


ATTENUATION [dB]
減衰量 [dB]
AMPLITUDE CHARACTERISTIC
振幅特性
GDT CHARACTERISTIC
ＧＤＴ特性
GDT[μsec.]
0
5
10
15
20
25
30
35
40
300
250
200
150
100
50
0
25
30
35
40
45
50
55
周波数 [kHz]
FREQUENCY [kHz]

【図８】 [FIG. 8]


ELEMENT THICKNESS AND ELEMENT SIDE LENGTH WHEN Fr = 40 [kHz]
Fr=40[kHz]の時の素子厚みと素子辺長
ELEMENT SIDE LENGTH L [mm]
素子辺長 L [mm]
60
50
40
30
20
10
0
0
0.1
0.2
0.3
0.4
0.5
0.6
拡がり振動
EXPANSION VIBRATION
FLEXURAL VIBRATION
屈曲振動
素子厚み t [mm]
ELEMENT THICKNESS t [mm]